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Research Article

Varying blood pressure in children: a diagnostic quandary interpreting the Fourth Report

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Abstract

Fourth Report guidelines on pediatric blood pressure (BP) are not clear when defining hypertension in children as "an average systolic BP and/or diastolic BP ≥ 95th percentile for gender, age, and height on ≥ 3 occasions." We aimed to determine the prevalence of pediatric hypertension in a screening population based on two different guideline interpretations. Prevalence of hypertension among 2094 students at four Houston area schools was calculated based on the *summation* or *sustained* model definition from Fourth Report guidelines. *Summation* hypertension definition required the single average of the BPs recorded across three visits to be elevated. *Sustained* hypertension definition required BP at each of three visits to be elevated. Hypertension prevalence by the *summation* method was 7%, whereas *sustained* prevalence was only 3.3%. Nearly a quarter of students had varying BP and were not classifiable by the *sustained* method but most would be classified as normal or prehypertensive by the *summation* method. The prevalence of hypertension among adolescents doubled depending on the interpretation of Fourth Report guidelines. Although methods in research studies can be clearly examined on publication of results, it is unknown which interpretation method is being used in clinical practice. J Am Soc Hypertens 2018;■(■):1–5.

Keywords: Blood pressure; guidelines; hypertension; pediatrics.

Introduction

Over the past several years, hypertension, a condition initially thought to be reserved for adults, has been gaining attention in the pediatric population. It is now recognized that the prevalence of hypertension in children and adolescents is between 2% and 5%.[1–4] Although the long-term implications of elevated blood pressure in children are largely unknown, it remains essential that we identify children who may have elevated risk for hypertension-associated sequelae later in life as well as children who have treatable causes of secondary hypertension. Since publication in 2004 until the very recent updated American Academy of Pediatrics hypertension guidelines for children,[5] the Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents (Fourth Report) has been the manual used by pediatricians to diagnose hypertension and the standard to define the prevalence of hypertension by epidemiologists for the last 13 years.[6]

The Fourth Report defines hypertension in children as "an average systolic blood pressure (SBP) and/or diastolic blood pressure (DBP) ≥ 95th percentile for gender, age, and height on ≥ 3 occasions." Prehypertension is defined similarly as "average SBP or DBP levels that are ≥ 90th percentile but < 95th percentile" or greater than 120/80 despite being less than the 90th percentile.[6] However, these definitions can be interpreted in one of two ways. Are they meant to be understood as the average blood pressure that is calculated at each visit should be elevated on three visits? Or is the definition meant to be construed as the single average of the blood pressures recorded across the three visits should be elevated?

Conflict of interest: The authors have no conflict of interest related to this work to declare.

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The first is a more conservative definition, ultimately requiring that a child have *sustained* elevated blood pressures to be labeled hypertensive. Classification according to this interpretation will henceforth be referred to as the *sustained model*. The second definition is less conservative and allows for a child with greater variability in their blood pressures to also be defined as hypertensive. This method of classification will be referred to as the *averaged/summation model*. Undoubtedly, not only does one's interpretation affect their overall measurement of prevalence but it also directly affects the care of individual patient. The primary goal of this study was to quantify prevalence rates of hypertension in children by the *summation* or *sustained* model definition based on Fourth Report guidelines. We expect that there is a significant level of overlap between these definitions in that children who fall consistently in one category will remain there regardless of the interpretation used. However, the interpretation of the definition is paramount in diagnosing the children whose blood pressures have greater variability and do not remain firmly in one classification.

Methods

Since 2000, the Houston Pediatric and Adolescent Hypertension Program at the University of Texas McGovern Medical School in Houston has screened blood pressure on over 20,000 students in 27 schools. Schools were chosen by convenience sample on the basis of having a population of enrolled students with a similar racial distribution to that of Houston. All students were eligible for screening with the primary point of contact being through physical education or health class. The screening protocol used was approved by the Committee for Protection of Human Subjects at the University of Texas Health Science Center at Houston and by school district Institutional Review Boards, where applicable. Consent was obtained from students' primary care taker per school district policy. At the remaining schools, all students were screened unless either the parent or student declined. This analysis includes only students from four schools screened since 2010 using a modified screening protocol that required blood pressure be measured on three occasions in all students with abnormal blood pressure at the initial screen.

Participating subjects completed an open-ended questionnaire including age, gender, race/ethnicity, or use of anti-hypertensive medication. Study personnel then measured arm circumference (cm), height (cm), and weight (kg). Study personnel consisted of paramedics, medical students, pediatric residents, fellows, and attending staff, who were all trained in the proper use of study equipment and measurement technique. A minimum of two oscillometric blood pressure readings were obtained with either a SpaceLabs 90217 (Snoqualmie, WA) or Dinamap Critikon (Tampa, FL) monitor. All measurements were taken with cuff size appropriate to arm circumference as outlined in the Fourth Report guidelines.[6] Blood pressures were taken up to four times at each visit while students were seated with at least 1-minute rest between measurements. The initial measure was discarded, and the remaining three were averaged to determine a final blood pressure status for the visit. If at the first visit, blood pressure was elevated $\geq$120/80 mmHg or the 90th percentile according to the Fourth Report standard based on sex, height, and age, the child underwent confirmation with two subsequent blood pressure checks. Follow-up measurements were performed within 2 months of the initial screen. Any child whose blood pressure was normal at the first screen did not undergo further testing. Students actively taking antihypertension medications were excluded. Blood pressure index was calculated as the mean blood pressure divided by the 95th percentile threshold value for sex, height, and age.

Categorical variables were reported as count (%) and tested by chi-squared or Fisher Exact tests. Continuous variables were reported as mean $\pm$ standard deviation (SD) and tested by Kruskal-Wallis test. A kappa statistic is reported to assess the level of agreement between the two model definitions. Stata 15 SE was used for all statistical analyses, and two-sided *P*-value of .05 was considered statistically significant.

Results

Between 2010 and 2015, 2168 students at four Houston area schools (two middle and two high schools) were screened and met inclusion criteria for the study. Children were excluded from the study if they had fewer than two systolic and diastolic blood pressures measured at each visit (n = 1) or were missing height, weight, sex, or age data (n = 9). Sixty-four children (3%) were excluded after measuring an abnormal first blood pressure but were subsequently lost to follow-up.

The remaining 2094 children consisted of 1252 (59.8%) females and 842 (40.2%) males (Table 1). Students ranged from age 10 to 19 years with a mean age of 14 years. The majority of students were self-identified as Hispanic or White but with good representation of both Asian and Black minorities. The racial breakdown in our population roughly aligns with the 2010 Census data in which population of the city of Houston consisted of 6% Asian, 23% non-Hispanic Black, 26% non-Hispanic White, 44% Hispanic, and 1% other races.[7] Mean height of students screened fell near the US average by Centers for Disease Control and Prevention percentiles (47.6th percentile), but mean weight and body mass index were slightly increased (63.2nd and 66.6th percentile, respectively). Overweight and obesity were seen in over one-third of the sample, in line with current US prevalence of 33.6% from National Health and Nutrition Examination Survey.[8]

At the first screen, the mean SBP measured was 113 (range 78–166, SD 11.0). Mean DBP at the first screen was 64 (range 44–94, SD 7.0). These values correlate to